R.M.

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Department of Electronics and Electrical Communication Engineering

End Spring Semester Examination 2016 — Full Marks : 100
Subject name: Electromagnetic Engineering — Time: 3Hrs
Subject No: EC21006

Answer all the questions
The marks for each question is indicated on the right.

1. In an air-filled rectangular waveguide operating at 6 GHz, the y-component of the electric field E_y of the TE mode is given by :

$$E_y = 5\sin\left(\frac{2\pi x}{a}\right)\cos\left(\frac{\pi y}{b}\right)\sin(\omega t - 12z)\,V/m.$$

Determine:

(a) the mode of operation.

(b) the cut off frequency of the mode.

(c) the intrinsic impedance of the mode.

(d) the x-component of the magnetic field (H_x).

[2+6+5+7=20]

2. A transmission line of length 2 m operating at $\omega = 10^6\ rad/sec$ possesses the following line parameters : $\alpha = 8\ dB/m$, $\beta = 1\ rad/m$ and $Z_0 = 60 + j40\ \Omega$. The line is connected to a source of complex amplitude $10\angle 0^0\,\mathrm{V}$ and source impedance of $Z_g = 40\ \Omega$ and terminated by a load of $20 + j50\ \Omega$. Determine :

(a) the input impedance seen by the source.

(b) the sending-end current.

(c) the current at the middle of the line.

[7+4+9=20]

3. Two $\lambda/4$ transformers in tandem are to connect a $50\,\Omega$ line to a $75\,\Omega$ (Z_L) load as in Fig. 1.

(a) Determine the characteristic impedance Z_{01} if $Z_{02} = 30\Omega$ and there is no reflected wave to the left of A.

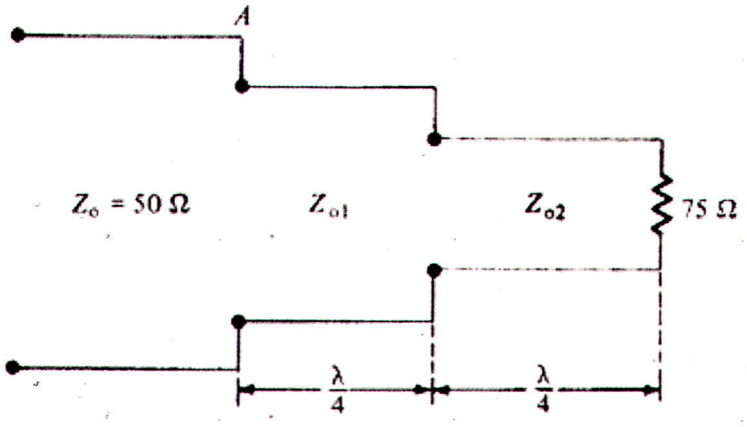

Fig. 1

(b) If the best results are obtained when

$$\left[\frac{Z_0}{Z_{01}}\right]^2 = \frac{Z_{01}}{Z_{02}} = \left[\frac{Z_{02}}{Z_L}\right]^2$$

determine Z_{01} and Z_{02} for this case.

[8+12=20]

4. (a) Show that in a rectangular waveguide :

$$u_p = \frac{u'}{\sqrt{1-\left[\frac{f_c}{f}\right]^2}} \quad \text{and} \quad \lambda = \frac{\lambda'}{\sqrt{1-\left[\frac{f_c}{f}\right]^2}}$$

where

u_p is the phase velocity inside the waveguide.

u' is the phase velocity in unbounded medium.

λ is the guided wavelength inside the waveguide.

λ' is the wavelength in unbounded medium.

fc is the cut-off frequency of the mode.

(b) For a waveguide operating at 20 GHz with dimensions 'a' and 'b' such that $a = 2b = 2.5\ cm$, calculate u_p and λ for the TE_{11} and TE_{21} modes.

[6+14=20]

5. A plane wave with the transverse magnetic field given by :

$$\overrightarrow{H_i} = 10\cos(10^8\,t - \beta z)\ \overrightarrow{a_x}\ \text{mA/m}$$

is incident normally from free space ($z \leq 0$) on a lossless medium with material parameters $\varepsilon = 2\varepsilon_0$, $\mu = 8\mu_0$ in the region $z > 0$.

Determine:

(a) the reflected electric field $\overrightarrow{E_r}$.

(b) the reflected magnetic field $\overrightarrow{H_r}$.

(c) the transmitted electric field $\overrightarrow{E_t}$.

(d) the transmitted magnetic field $\overrightarrow{H_t}$.

[7+3+7+3=20]